Exploration Beyond LEO: Process and Progress

"Architecture Options for Exploration Beyond Low Earth Orbit [LEO]" is one of four subcommittees that have been formed within the Review of Human Space Flight Plans Committee. The four subcommittees are working in parallel to perform fact-finding and analysis for consideration by the full committee. This process is proceeding in parallel with the gathering of important data and public input by the full committee. In public deliberations, the full committee will consider key data and analysis gathered and undertaken by the four subcommittees, and endeavor to fuse them into a set of coherent options for the consideration of the administration.

The necessity of the four subcommittees working in parallel is mirrored in the work of the "Exploration Beyond LEO" subcommittee itself. While no high-level conclusions about the goals of human space flight have yet been reached by deliberations of the full committee, the subcommittee is undertaking studies of different exploration options that entail different destination strategies, transportation infrastructures, and roles for technology development and partnerships. The full committee will evaluate these studies, and the extent to which these scenarios fulfill human space flight goals considered by the committee.

Specifically, the "Exploration Beyond LEO" subcommittee will examine the following questions: (1) What are the appropriate destinations and sequences of exploration for human exploration beyond LEO; (2) What should be the mode of surface exploration (if any); (3) What is the strategy within the human space flight program for *coordinating* human and robotic exploration; (4) What are the assumed launch vehicle(s) to LEO (in terms of mass to orbit and shroud diameter); (5) What are the options for in-space fuel/oxidizer storage and transfer; (6) What is the role that space technology research and development will play; (7) What is our strategy for engaging international partners in the development of the program; and (8) What is our strategy for engaging commercial entities?

These questions can be examined individually in trade studies, or by constructing several integrated scenarios. The subcommittee is pursuing a mixed approach, in which the questions that are more tightly coupled (1-3 above) will be examined in scenarios, and the less tightly coupled issues as individual trade studies.

Destination strategy questions, and related questions 2 and 3, are being examined via seven scenarios, including five defined by the subcommittee. The intention of the

¹ The four subcommittees are: ISS/Shuttle; Exploration Beyond LEO; Commercial, International, and Interagency (Integration); and LEO Access. A graphic naming the four subcommittees and showing their committee membership may be downloaded at http://www.nasa.gov/offices/hsf/home/index.html.

scenarios is to include a broad enough range of possibilities to span the total space of exploration options. Many of the elements of these scenarios can be mixed and matched; that is to say, many other combinations are possible. The purpose of defining these scenarios is to study the integrated combination of choices in context so that they can be better understood. The subcommittee will proceed in at least two rounds in its study. The second round will look at architectures in terms of their capabilities to support ongoing exploration as well as particular destinations. These initial scenarios are those for the first round. In the second cycle, we will examine additional scenarios, or recombine and refine elements as directed by the full committee.

The subcommittee's five initial scenarios are labeled as *Lunar Base*, *Lunar Global*, *Moon to Mars*, *Mars First* and *Flexible Path*. In addition, we have asked the Constellation program to document the program of record as a scenario, and invited them to propose an alternative as well.

The first subcommittee-defined scenario, *Lunar Base*, is a close derivative of the current program, with some simplifications. Lunar Global is a scenario in which a base or outpost is not assembled on the Moon, but instead the Moon is explored by a coordinated series of extended duration human sorties and robotic exploration. In both these cases, implications for subsequent Mars exploration will be considered. *Moon to* Mars, or more completely Moon on the way to Mars, is a scenario in which the primary objective is Mars exploration, and all systems are designed for Mars. Only when it is beneficial to use the Moon as a true test bed for these Mars exploration systems will flights to the Moon be conducted. *Mars First* is a plan to exclusively pursue human exploration of the Mars as fast as possible, without using the Moon as a first destination. Finally, Flexible Path is a scenario that allows humans to visit a wide number of inner solar system bodies, objects and locations, but not go to the surface of those with deep gravity wells. Destinations besides Moon and Mars would include the Earth-Moon and Earth-Sun Lagrange points, near-Earth objects (NEOs) and the moons of Mars. There is nothing implied in this scenario that surface exploration might not follow, simply that exploration would first exploit all that could be done without landing on a planetary surface.

The transportation infrastructure decisions (decisions 4 and 5) will be examined as a comprehensive trade space of launcher vehicles, depoting and destinations. That is, we will examine the possible in-space transportation infrastructure to all likely destinations for each of the launch vehicle classes, with each of the depoting concepts.

Finally, questions 6, 7 and 8 are qualitatively different than the first five questions. The first five are more technical, and arguably more tightly coupled. The issues of involvement of international partners and commercial entities could more easily be mixed and matched in the scenarios. Therefore these issues will be examined separately from the more technical questions.

This initial set of seven scenarios and trade studies will allow the integrated study of these questions and choices in the first cycle of analysis, to be completed in time for deliberation during the public meetings of the full committee on 28-30 July.